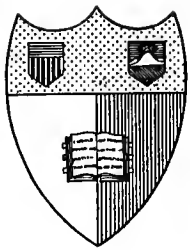
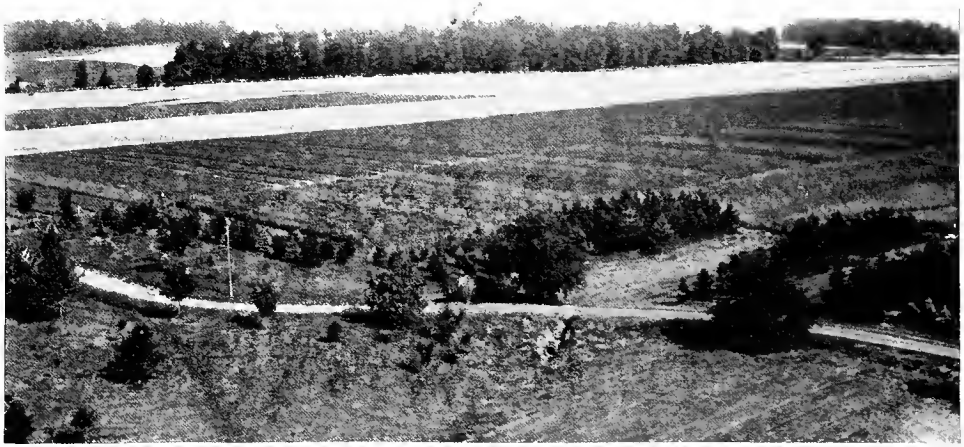
Timely Soil Topics





THE EXPERIMENT STATION TEST IS THE REAL TEST.

TIMELY SOIL TOPICS

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THE AUTHORS
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DEDICATED
TO THOSE
WHO BELIEVE IN AND WHO PRACTICE
A
PERMANENT SYSTEM OF SOIL IMPROVEMENT

PREFACE

Timely Soil Topics in its present form is the outgrowth of a series of four-page pamphlets written monthly during the year 1918-19 by members of the Department of Agricultural Chemistry and Soils of The Ohio State University. Only a limited number of these pamphlets were distributed.

The demand for the Timely Soil Topics has continued to increase. Accordingly, it seemed desirable to assemble the material contained in the first thirteen numbers and publish it in one volume for the benefit of those who have not had opportunity to read the pamphlets as they appeared. The subject matter has been revised and rearranged and is now presented in this little volume. Only a limited edition has been published. If the demand justifies, this volume will be enlarged and revised at the end of another twelve months to include those Timely Soil Topics which have been published during that period.

THE AUTHORS

Ohio State University
June 1, 1919

ACKNOWLEDGMENTS

We are indebted to Mr. J. E. McClintock and to Mrs. E. M. Cadley for many helpful suggestions in editing Timely Soil Topics during the period when they were being published in pamphlet form, and for valuable assistance in planning the present volume. We wish also to record our indebtedness to Miss Orleta Ansel for services rendered in the preparation of the manuscript.

Acknowledgment is due the Ohio Experiment Station for illustrations furnished. Finally we are desirous of expressing our gratitude to all those whose kindly interest has been a source of encouragement.

THE AUTHORS

The Ohio State University

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PREPARATION FOR WHEAT

JUNE — NO 1

A program for wheat production in Ohio for the coming years may logically look to the growing of as many acres of wheat in each county as that county ever grew before, and then to making every effort to produce as large yields per acre as practicable. This would mean for the state more than 3,000,000 acres and certainly 20 bushels or more per acre, making 60,000,000 bushels of wheat as an altogether reasonable expectation with favorable prices as an encouragement to growers.

Ohio's Wheat Record

Period	Farm Price Dec. 1	Acres	Bushels	Bu. per Acre
1877–81	$1.02	2,394,000	38,242,000	16
1882–86	.78	2,586,000	33,504,000	13
1887–91	.80	2,336,000	32,210,000	14
1892–96	.58	2,528,000	35,056,000	14
1897–01	.64	2,502,000	32,248,000	13
1902–06	.73	1,907,000	39,882,000	15
1907–11	.91	1,898,000	29,852,000	16
1912–16	1.01	1,623,000	23,822,000	15
1917	2.00	1,870,000	41,140,000	22
1918	2.00	2,290,000	43,225,000	19

Ohio's wheat acreage had been rapidly decreasing until 1917. With a continued need and high prices, there is every reason why the acreage should

again reach 3,000,000. The very high average yield per acre last year (1917) was due mainly to especially favorable weather conditions.

Early Plowing Brings Higher Yields

There is much data and a large fund of general experience to the effect that early and thoro preparation of the seedbed for wheat is one of the greatest factors in high yields. The evidence from the Kansas Experiment Station, in that part of the state where the average rainfall is about 30 inches, is conclusive.

July and August Is the Time To Plow for Wheat

Date of plowing	Depth	After wheat 3-year average	After wheat 1913	After Oats 1913
		Bu.	Bu.	Bu.
July 15	3 in.	21	22	44
July 15	7 in.	27	35	45
Aug. 15	7 in.	23	33	41
Sept. 15	7 in.	14	18	28

To extend the area of wheat, it will be necessary to do more plowing. Old pasture and meadow land make excellent sites for wheat when plowed early and worked down. This applies as well to oat stubble. Most cultivated crops, especially potatoes and beans, when kept free of weeds and harvested in time, leave excellent conditions for wheat. Deep disking will then take the place of plowing.

The idea to be kept in mind is a fairly deep but compact seedbed, prepared in time to store up a supply of moisture and available plant food, and with enough fine soil on top to insure complete and uniform covering of seed to a depth of about one inch.

Acid Phosphate Pays

Data from the Ohio Experiment Station, obtained in different parts of the state, leave no doubt of the great value of the use of a liberal amount of acid phosphate for wheat. Of the phosphate applications mentioned in the table, 120 to 200 pounds were applied to wheat, and the remainder to the other grain crops in the rotation.

One Hundred Pounds of Acid Phosphate = Two to Four Bushels of Wheat

County	Rotation	Length of experiment	Acid phos. per rotation	Yield per acre	Inc'e due to acid phos.
		Yrs.	Lbs.	Bu.	Bu.
Wayne	C.O.W.Cl.T.	23	320	19.7	8.0
Wayne	P.W.C.	23	320	36.2	6.0
Cuyahoga ...	C.O.W.Cl.T.	20	320	15.3	6.6
Montgomery.	C.W.Cl.	13	240	14.2	5.3
Meigs	C.W.Cl.	13	240	16.1	5.3
Hancock	C.O.W.Cl. ..	7	360	10.4	4.9
Miami	C.O.W.Cl. ..	5	500	27.0	9.4
Clermont. ...	C.S.W.Cl. ..	4	500	22.7	9.1
Hamilton ...	C.S.W.Cl. ..	3	500	22.6	8.6

Acid phosphate at $25.00 per ton would be very profitable, even if the entire application were charged to the wheat crop. At Wooster the value of the increase on the 5-year rotation from the use of 320 pounds of acid phosphate amounted to $37.20, of which the wheat increase represents $16. These computations and others following are made on the basis of corn at $1.00, oats 60 cents, and wheat $2.00 per bushel and hay $20 and acid phosphate at $25 per ton.

Factory Mixed Fertilizers too Expensive

Since acid phosphate returns from $5 to $10 worth of increase crop for every $1 invested, the question arises as to how much heavier applications than the above can be made before it becomes more profitable to buy nitrogen or potassium. Some of the best data on this question are from experiments conducted for 8 years at Strongsville, comparing four brands of factory-mixed complete fertilizers with bone meal. The complete fertilizers were a 4-8-4, 2-10-1, 2-8-1, and 1-6-1. The rotation was corn, wheat, and clover. The four mixtures and bone meal were each applied at the rate of 200 pounds per acre on corn and 200 pounds on wheat. The results showed that the factory-mixed fertilizers increased the yield of wheat on the average 9 bushels, while the bone meal increased the yield of wheat 14 bushels per acre. The increase in corn and clover was in about the same proportion. At present prices the factory-mixed fertilizers pro-

duced increase to a value not to exceed $3.60 for each $1.00 invested, while bone meal gave at least $6.30 for each $1.00 invested.

The higher the proportion of phosphorus in a fertilizer, the more profitable the investment, and this usually means the application of nothing but a straight phosphate.

How much Acid Phosphate?

We may safely conclude that at least 300 pounds per acre of acid phosphate, or its money equivalent in some other phosphorus carrier, may be used on wheat before it is as profitable to spend part of the money for nitrogen or potasium. Furthermore, phosphorus up to at least this amount is so profitable that its application can not well be omitted.

These fertilizer experiments have all been on light colored, well worn soils having, with one or two exceptions, a very low unfertilized yield, and especially in need of more available nitrogen and potassium. When more organic matter is supplied by heavier sods, crop residues, and manure, deficiencies of nitrogen and potassium are rapidly made up, but phosphorus becomes relatively more important, and so greater profit is secured from its use. On better farms, therefore, phosphorus will usually give higher returns than in these experiments. The results on dark brown corn land at the Illinois Experiment Station in a rotation of corn, oats, wheat, and clover are evidence on this point. An application of $3.50 worth of phosphate

per acre on manured land produced an increase of 12 bushels of wheat per acre as an average of 7 years.

Phosphate Rock Better Than Mixed Fertilizers

At present prices (1918) of nitrogen and potassium in mixed fertilizers much more profitable returns would result from investing in raw rock phosphate. Where manure is used, or the soil is well stocked with organic matter to supply available nitrogen and potassium, there should be no hesitancy in deciding to use this material. At Wooster, 320 pounds of rock phosphate with 8 tons of manure applied to the corn crop increased the following wheat crop by 4 bushels per acre, as an average for 20 years in a corn, wheat, and clover rotation.

The best data the Ohio experiments afford as to relative profitableness of mixed fertilizers and rock phosphate on land low in organic matter, and below the average in fertility, is from the rock phosphate treatments at Strongsville. Here the evidence is in favor of rock phosphate at the rate of 1 to 1½ tons per acre each 5 years, as against the same or a larger expenditure for mixed fertilizers.

Land below the average in fertility, and which has not recently felt the rejuvenating effect of clover or manure, may well have some commercial nitrogen in addition to a large ration of phosphorus, but the nitrogen should be used as a top dressing to the wheat early in the spring.

A Good Place For Limestone

Limestone is badly needed on the greater portion of the wheat land in Ohio. The time of preparation for wheat is a particularly favorable opportunity for liming, since it anticipates the clover, alfalfa or timothy seeding to be made with wheat next spring. At Wooster, the use of 2 tons of ground limestone once in 5 years has increased the wheat crop by an average of 6.5 bushels per acre on otherwise unfertilized land and by a greater amount on phosphated land. On acid soils limestone is the most profitable investment after the phosphorus requirement has been met, and its effect on other crops to follow is greater than on wheat.

LIMESTONE AND WHEAT

JULY — NO. 2

Mr. George P. Williams, a prominent and progressive farmer in Delaware County, Ohio, contributed an article in the Ohio Farmer under date of March 9, 1918, entitled "Quick Results from the Use of Lime." In this article certain fundamental truths have been pointed out which bear on the subject of the use of limestone on wheat. The following quotations are taken from this article.

Limestone Boosts the Clover

"Some years ago a neighbor of ours applied a considerable amount of lime to one of his fields, intending to sow alfalfa; his plans were changed, and the field was seeded to wheat, followed by medium red clover. The seed crop was cut after having first taken off a crop of clover hay, and a yield of approximately 4 bushels of seed per acre was recovered. The same year the fields around this farm were scarcely profitable when cut for seed, and many were not worth cutting."

Growing Clover for Seed

"Altho it is a recognized fact that the presence of sufficient lime in the soil is highly advantageous to clover-hay production, I have not seen any effort at developing the practice of applying lime as a means of securing a crop of clover seed, which

A Part of the Preparation for Clover.

being easily and immediately convertible into cash, would reimburse the farmer so early for the first cost of liming."

"With the high cost of improved implements, of buildings, of tile, of fertilizer, and of lime the farmer of limited means or the man who is trying to pay for his farm, has to plan his expenses with a view to returns, both speedy and certain. The harvesting of second-crop clover for seed requires little labor; the attractiveness of having one's own seed and thus saving the high cost of spring seeding, both would impel the farmer to lime a trial field with the rather strong indication of a good seed crop on account of liming. The possibility of developing a profitable money crop, and, at the same time, incidental to the production of a heavy crop of clover hay is surely not theory pure and simple. It appears to the writer as a rational means of giving the use of lime an impetus not previously observed, especially in the practice of the great class of small farmers who are trying to limit farm expense to the things that yield quick and certain returns and benefit the farm as well."

Limestone Helps the Wheat

Mr. Williams has pointed out the desirability of applying limestone as a means of insuring a good growth of clover. He indicates that in his section this would mean applying the limestone to the wheat for the benefit of the clover following. A question arises as to what effect this application

of limestone would have on the wheat itself. Many extremely acid fields are sown to wheat each fall. If it can be shown that the application of limestone will not only be of benefit to the clover crop, but that it will also have an immediate effect on the wheat, it would seem all the more desirable, therefore, to apply the limestone to the soil before it had been sown to wheat rather than to wait, as is ordinarily done, until the corn crop occurs in the rotation. Judging from the experiments conducted at Wooster as to the effect of limestone on crops it would appear that an increase of from 2 to 7 bushels of wheat could be secured from an application of 2 tons of limestone. In these experiments limestone was applied at the rate of 2 tons in 5 years on the corn crop which was followed by oats, wheat, clover, and timothy. If limestone had been applied to the wheat directly, it is reasonable to expect that a similar or greater increase might have been produced. It is a recognized fact that on acid soils not only clover, but all the crops in the rotation as a rule are benefited by an application of limestone.

Preparing in Advance

Limestone should be ordered considerably in advance of the time at which it is expected to be used. Delay may mean slow delivery and a lost chance to increase the wheat crop, as well as a lost opportunity to secure a very valuable crop of clover following the wheat. During the summer, the

roads are in excellent condition for hauling and very often a plowed wheat field is available for spreading the stone as it is hauled. This materially reduces the labor of handling the limestone as compared to what it is when this material must be stored in piles or under cover. A cooperative purchase of limestone in large amounts will enable the securing of much better prices than where each farmer attempts to secure a small quantity of limestone for his individual use.

A Chance to Renew Worn-out Sods

The growing of a crop of wheat offers an excellent opportunity to rejuvenate old pastures that are not too steep for cultivation. Where such pastures are acid they may be plowed early and thoroly worked down, then given a liberal application of limestone and acid phosphate with the prospect of growing a crop of wheat that will more than pay for the cost of treatment. A light top dressing of manure during the fall or winter, altho not necessary, will increase the chance of a successful catch of grass. Given treatment of this kind, these worn-out pastures can be changed in less than 2 years from an unprofitable to a profitable condition. At the same time the total production of wheat can be materially increased. Two very desirable things will have been accomplished with one set of operations.

Limestone and Acid Phosphate Make a Good Team

In the same way that labor conditions have brought about the use of larger implements and three- or four-horse teams, so will economic conditions necessitate a larger and more thoro team work in the improvement of soils. Acid phosphate and limestone make an excellent lead team where legumes and manure are behind them. "Acid phosphate on every acre, limestone where needed," well might be made our watchword. Given an average season, most excellent wheat can be grown all over Ohio each year by making liberal use of no other commercial materials. These two materials should be supplied in liberal amounts before money is expended for nitrogen and potassium.

The Increased Cost of Limestone

It is to be expected that the increased cost of operation of limestone plants, because of the competition for labor and the higher price of grinding machinery, will result in a higher price being asked for agricultural ground limestone. It is difficult to say how much of a rise in price is justified. One large manufacturer of agricultural ground limestone is still quoting his product at $2.00 per ton, f. o. b. his plant. (1918).

We wish to point out, however, that it is easier to make a profit on limestone at present prices of farm products than ever before. A reasonable increase in the cost of limestone should not prevent the purchase of this material in liberal amounts for fall use. Some plants report that as much as

60 percent of their product is sold in sacks. It would seem desirable to encourage the buying of limestone cooperatively in bulk instead of paying the usual sacking cost of $1.75 per ton.

In the Absence of Limestone, More Acid Phosphate

As wheat-seeding time approaches there will always be many who have not secured lime, but who wish to grow as much wheat as possible. Very creditable yields may be secured on acid soils by the liberal use of acid phosphate on a well-prepared seed bed. For those men who own farms and will have control of them for two or three years hence, from 400 to 500 pounds of acid phosphate per acre is a safe investment on wheat in the absence of limestone. This larger amount of acid phosphate not only will make a greater yield of wheat more certain, but will also help to insure a better catch of clover.

FACTORY-MIXED FERTILIZERS

AUGUST — NO. 3

It seems desirable to explain clearly our position concerning the use of mixed fertilizers. By mixed fertilizers we mean those fertilizers that contain any two or all three of the common commercial plant food elements derived from two or more sources and mixed in definite proportions to give certain formulae. The majority of such mixtures are made from materials which have little or no value for other purposes. It has been the stock argument of the advocates of mixed fertilizer that it is desirable to make use of those materials which would otherwise be entirely wasted. The slaughter houses, tobacco warehouses, sewage disposal plants, and manufacturers of various products are anxious to dispose of all the substances which accumulate in their plants as by-products of manufacturing processes. The mixed fertilizer industry affords an excellent dumping ground for many of these wastes.

Waste Products Should Be Utilized

We agree with the fertilizer companies as to the desirability of using all the products which have a fertilizing value and which, if not used as fertilizers, would be wasted. A question which arises is: What is the farmer justified in paying for these

Acid Phosphate Made the Difference.

materials? The answer necessitates the discussion of three points:

(1) The importance of nitrogen and potash as fertilizing materials.
(2) The availability of these substances in mixed fertilizers.
(3) The prices at which they must sell to be good investments on the average farm.

Evidently the answer to the last will be determined by the answers to the first and second.

Factory Mixing Not Necessary

It must be kept in mind that every farmer has the privilege of buying any of the elements of plant food separately in highly available forms. The chief reason for buying them mixed is one of convenience. It would seem that it should be possible to mix fertilizing materials more economically by machinery than by hand, but experience shows that such is not the case, if we are to judge from the prices at which mixed fertilizers are offered for sale. There is no evidence that factory-mixed fertilizers cannot be duplicated on the barn floor.

Corn, Oats, Wheat, Clover, and Timothy are Chief Ohio Crops

Statistics compiled by the State Board of Agriculture show that there are approximately 20,000,000 acres of land in Ohio farms. Of this amount only about one-half is in rotated crops, the remainder being in pasture, woodland, or lying waste. Ninety-five percent of the 10,000,000 acres of rotated crops are corn, oats or barley, wheat or

rye, clover or other legumes, and timothy or other grasses. This means that tobacco, potatoes, sugar beets, truck, and all other crops grown in Ohio do not total one-half million acres. This shows that the chief business of Ohio farmers is the growing and disposing of corn, oats, wheat, clover, and timothy. The discussion of the problem will, therefore, be confined to these crops.

Acid Phosphate Always Important

The experimental evidence in favor of acid phosphate is such as to leave no doubt in the minds of the best farmers of the desirability of buying and applying it in liberal amounts. Acid phosphate used alone on most soils gives a handsome profit on the investment. Neither nitrate of soda nor muriate of potash when used alone at pre-war prices on corn, oats, wheat, clover, and timothy has given a profit on the investment at any of the experimental farms in Ohio. The fertilizer-mixing companies, recognizing that the fertilizer must contain phosphoric acid to be effective, make up their fertilizers with a high content of acid phosphate and with small amounts of nitrogen and potash.

Nitrogen and Potash Also Important

Fertilizer experiments on a rotation of corn, oats, wheat, clover, and timothy have been under way at the Ohio Experiment Station Farm at Wooster for the last 25 years. The yield of crops resulting from the use of acid phosphate alone and in combination with nitrate of soda and muriate of potash are shown in the following table:

Twenty-Year Average Yield Per Acre at Wooster

Crop	No fertilizer	Acid phosphate	Acid phosphate and nitrate of soda	Acid phosphate, nitrate of soda and muriate of potash
Corn	29 bus.	37 bus.	43½ bus.	47 bus.
Oats	30 bus.	39½ bus.	45½ bus.	49 bus.
Wheat	10½ bus.	18½ bus.	24 bus.	27 bus.
Clover	1800 lbs.	2450 lbs.	3050 lbs.	3200 lbs.
Timothy ...	2150 lbs.	2700 lbs.	2550 lbs.	3100 lbs.

It is evident that the use of nitrate of soda and muriate of potash materially increased the yield when applied in addition to acid phosphate. The acid phosphate used in the above experiment would cost at present prices $3.85 per acre every five years; the nitrate of soda, $28.85; and the muriate of potash, $32.50. It will be seen that the acid phosphate is not only the cheapest of the three, but also the most effective. We believe that at present prices (1918) the evidence is in favor of buying only acid phosphate.

Manure and Clover Supply the Nitrogen and Potash

In 1897 a second experiment was begun by Director Thorne in which to test out the value of acid phosphate as a reinforcement for manure. It was decided also to change the rotation in this experiment to a 3-year rotation of corn, wheat, and clover in order to give a better opportunity for se-

curing more nitrogen from the air. The results are shown in the accompanying table:

Sixteen-Year Average Yield Per Acre at Wooster

Crop	No fertilizer	Manure	Manure and acid phosphate
Corn	35 bus.	60 bus.	67 bus.
Wheat	11 bus.	21 bus.	26 bus.
Clover	2750 lbs.	4250 lbs.	5100 lbs.

The yields in this case are much higher than in the 5-year rotation even where the complete fertilizer was used. The only logical explanation of this is that manure and clover supply the nitrogen and potash. The application of manure was 8 tons and of acid phosphate 320 pounds per acre every 3 years on the clover sod for corn.

Thirteen Tons of Manure Available for Corn

Mr. C. G. Williams has recently reported the results of an experiment to determine how much manure is available on the livestock farm. The rotation followed has been corn, soybeans, wheat, and clover. The land received 400 pounds of acid phosphate and 2 tons of ground limestone per acre each rotation. All of the crops with the exception of the wheat grain were fed to livestock and the manure saved and weighed. This manure was applied to the clover sod for corn. The average amount of manure produced has been 13.35 tons per

acre every 4 years. This is equivalent to 10 tons every 3 years. The crop yields were 64½ bushels of corn, 22 bushels of soybeans, 32½ bushels of wheat, and 2¼ tons of clover hay as an average of 7 years.

What About the Grain Farmer?

The fertilizing-mixing companies point out that some men are not livestock farmers, and that therefore they should use nitrogen and potash in the form of mixed fertilizers. The question is: "Can the grain farmer afford to buy nitrogen and potash in mixed fertilizers?" Some years ago Director Thorne conducted some comparisons between factory-mixed and home-mixed fertilizers. The brands used were 4-8-4, 2-10-1, 2-8-1, and 2-6-1. The home-mixed fertilizers contained the same amounts of plant food in high-grade carriers. As a result of this experiment it was shown that factory-mixed fertilizers on the average were only 80 percent as effective as the home-mixed material. At the same time the former were considerably more expensive.

The price of nitrogen in fertilizers is regulated by the price of nitrate of soda, and the price of potash by muriate of potash. If these materials are scarce, the nitrogen and potash in mixed fertilizers take a smypathetic rise in price. It would seem that the selling price of mixed fertilizers is determined by "what the traffic will bear" and not by the cost of materials. Acid phosphate is quoted

(August, 1918) at $26.50, a 1-8-0 fertilizer at $28.25, and a 1-8-1 at $35.00 per ton. In the first case it apparently costs 75 cents per pound to put the nitrogen in the fertilizer. In the second case it costs 34 cents per pound to add the potash.

Commercial vs. Home Grown Nitrogen

It is desirable to keep in mind that crops use large amounts of nitrogen. A 100-bushel corn crop removes 150 pounds; a 100-bushel oat crop, 100 pounds; and a 50-bushel wheat crop, 90 pounds of nitrogen from the soil. A ton of 1-8-1 fertilizer contains only 20 pounds of nitrogen. The man who applies 200 pounds of such a fertilizer is adding 2 pounds of nitrogen to his soil, about one-fourth as much as comes down in the rain every year on the same acre. Such a use of fertilizer only hastens land ruin. We must have some other source of nitrogen, and that source is the clover crop. A 3-ton crop of clover contains 120 pounds of nitrogen, or as much as is found in 6 tons of 1-8-1 fertilizer. The clover also contains an equal amount of potash. For the grain farmer the clover crop, straw, and stover must be plowed under. With such a system of farming, coupled with the use of acid phosphate and limestone, Mr. C. G. Williams has averaged 58½ bushels of corn, 19 bushels of soybeans, and 28½ bushels of wheat for the last 7 years, and apparently the grain farming is gaining on the livestock system of farming as to crop yields.

PHOSPHATE AND MANURE MAKE AN EXCELLENT COMBINATION FOR CORN.

PHOSPHATE ROCK

SEPTEMBER — NO. 4

The first serious effort on the part of farmers to supply phosphorus came with the use of bone, and the movement grew until on many farms "bone meal" became the only password which would secure entrance for the fertilizer agent. But, as our farming area expanded, it soon became evident that some other source of phosphorus would be necessary, if the productivity of the soil was to be maintained and increased.

Acid Phosphate as Effective as Bone

Acid phosphate has served to supplement bone meal in meeting the steadily increasing demand for phosphorus. At first it did not find ready favor among the great majority of farmers. But, as experiments and experience proved the value of acid phosphate, prejudice against it rapidly disappeared, and at the present time acid phosphate is even more popular than bone. A great number of farmers in the state are today confining their purchase of fertilizers to acid phosphate. In fact, it has become so popular that the fertilizer companies are experiencing great difficulty in selling anything but acid phosphate.

Fortunately phosphate rock offers a source of phosphorus that can be used to advantage on many

Phosphate Rock Becoming More Popular

Ohio farms. Just as acid phosphate was utilized to supplement the diminishing supply of bone meal, so will phosphate rock be used to supplement acid phosphate in meeting the increased demand for phosphorus. Unhampered by prejudice against it, phosphate rock will find a more ready reception than was accorded acid phosphate 30 years ago. Many thinking farmers are today using phosphate rock. Others only await further encouragement before beginning the practice.

For 20 years the Ohio Station has been studying the possibilities of the use of this material. The results that have obtained are very encouraging. The most promising method of application has been to mix the raw rock with manure, either in the stable or covered barnyard. It has been the practice at Wooster to scatter the phosphate rock over the manure at the rate of 40 pounds per ton. Eight tons of manure were applied to the clover sod plowed under for corn. The results obtained follow:

Manure and Rock Phosphate Test at Wooster

[18-year Average Yields per Acre]

	Corn	Wheat	Clover
	Bus.	Bus.	Lbs.
Manure	59	22	4,000
Manure and rock phosphate	67	26	4,750
Increase for rock phosphate	8	4	750

If corn is worth $1.50 per bushel, wheat $2.00 per bushel and clover hay $20 per ton, the value of the increase produced by rock phosphate would be $27.50. The cost of 320 pounds of rock phosphate at the present (1918) time, delivered to most points in Ohio, need not exceed $1.60.

Ohio is a Livestock State

A very large amount of manure is produced in Ohio. Each year marks an increase in the use of concrete floors, manure sheds and covered barnyards. With such conditions existing, rock phosphate unquestionably can go far toward taking the place of acid phosphate. Instead of 40 pounds per ton of manure, the amount used well may be increased to double this amount or even more. The labor of applying the estimated amount once a day in the stable or twice a week in the covered yard is a very minor point.

The greater part of the manure is applied to land intended for corn. The use of rock phosphate with manure is a means of saving labor during the busy spring season prior to corn planting. Phosphate rock mixed with manure and applied with it means that the time consumed in drilling acid phosphate just before planting corn can be utilized in other ways. This is a matter of considerable importance, especially when the seedbed is in shape and weather conditions are right for planting.

Both Director Thorne and Mr. Williams express the opinion that rock phosphate can be used profit-

Rock Phosphate and Manure a Good Combination

ably with manure on many Ohio farms. Expression of this opinion in no way detracts from the very high esteem in which acid phosphate is held, as it is recognized that present-day conditions justify a greater use of both of these admittedly profitable materials. They call attention, however, to the fact that there should be intelligent direction of its use. Just as with acid phosphate, best results are secured only when supplementary nitrogen and potassium are supplied either thru clover sods or manure.

One Ton per Acre

The amount used with manure may vary from 500 to 1000 pounds per acre per rotation of 3 or 4 years. A practice which some may try to follow, and one which by all means should be discouraged, is to drill a small amount of rock phosphate on the soil in the same way that acid phosphate is usually applied. Such attempts lead only to dissatisfaction, and do harm to the cause of rock phosphate. If it is to be applied directly to the soil it should be plowed down with the second growth of clover at the rate of 1 ton per acre. A few farmers are using it in this way with success, but Director Thorne believes that his tests both at Strongsville and Wooster indicate that mixing with manure is the more preferable method.

Looking Forward

The use of phosphorus on Ohio soils is sure to increase. The condition as regards the corn, wheat, and clover crops of future years cannot be fore-

seen. Perhaps acid phosphate will continue to be the most popular source of phosphorus. Nevertheless, it is probable that there are a rather large number of farmers in Ohio who might be interested in the matter of applying rock phosphate and manure to the corn crop as a means not only of growing a profitable crop of corn but also of supplying, partially at least, the phosphorus requirements of other crops in the rotation. This would be not only a step toward a practical solution of the phosphorus problem, but also a logical reply to those fertilizer dealers who insist on converting all of their acid phosphate into mixed fertilizers.

There are numerous indications that Ohio farmers, altho retaining their proper appreciation of acid phosphate and bone meal, will use increasing quantities of rock phosphate.

SWEET CLOVER

OCTOBER — NO. 5

Sweet clover can well be an extensively grown crop in Ohio, at least equalling red clover in acreage. Its value for feed and for soil improvement make it second to no other legume in importance. It grows well on land too hard, too poor, or too wet for red clover or alfalfa, and will prepare such land for these other legumes. At the same time no one need excuse its presence on the best land in the state. In fact, the dark soils in the northwestern section are taking the lead in the growing of sweet clover in Ohio at the present time. But the coming of sweet clover is to extend the acreage of legumes. To sound its praise does not involve casting a stone at any other crop. To all those who are well satisfied with the legumes they are growing, and who are sure they are growing a sufficient acreage of the same, sweet clover is not even suggested.

A Good Yielder

Sweet clover compares well with mammoth clover in total tonnage during the period of its growth. Sown on wheat ground in the winter or early spring it usually cuts 1 to 1½ tons per acre of cured hay about September first of the same year. Another crop, 1 to 2 tons, is ready before June first

Without Limestone Sweet Clover Is a Failure.

next year. After this it may be cut again for hay in July or allowed to stand for seed. If hay is made a second time during the season there will still be an aftergrowth good for pasture or plowing under; or it will make enough seed to reestablish itself the following season.

Sweet clover is killed by cutting when the plant has attained near full growth for the first season or has approached the blossom stage in the second. But it makes the best hay before this, while the stems are fine and covered with leaves. To insure the next growth it is necessary to leave a certain amount of foliage on the stubble. This means pointing the cutter bar up; yet when the plants are big they can not be cut high enough, for the lower parts of the stems have only dead leaves. Some growers cut the June hay crop with a grain binder. This insures cutting it high and makes it convenient handling the hay. The bundles are allowed to stand in long narrow shocks until cured.

As a seed crop sweet clover is very prolific, producing easily 5 bushels per acre. But it shatters very badly and the greater part of the seed will be lost if this fact is not taken into account. It can be threshed very well by a grain separator. Whether the first or second growth of the season will make the better seed crop is an open question. There are a good many advantages with the second. This permits of using the first crop for hay. The second

crop is not as rank and can be more readily handled. A good many instances are known where a hay crop and 5 or 6 bushels of seed have been produced the same season.

Sweet Clover Pasture

When sweet clover is seeded with grain in the spring it is ready for pasturing in early August and can be pastured at the rate of 2000 pounds of live-stock per acre until late fall. It is ready again early the following spring and can be pastured heavily all the second season. Under these conditions it will reseed itself for permanent pasture if desired. In addition other grasses and clovers will naturally come in and make a heavy sod. All classes of live-stock do well on this pasture and there is not the danger of causing bloat in cattle as in the case of other clovers or alfalfa.

A High Feeding Value

In feeding value sweet clover is very nearly equal to alfalfa, when cut or pastured before the stems get old and woody. Among those who have only heard of the crop or seen it along the road-side, the objection is often raised that stock do not like it. The testimony of experienced growers is quite to the contrary. Many dairymen have said that cows more easily acquire a liking for sweet clover hay or pasture than they do for corn silage. It is true that sweet clover has a taste peculiar to itself and that stock, like people, are often finicky about what they eat, and do not always take up with a new food unless they are at first coaxed or

driven to it; then they may become fond of it. Like alfalfa, sweet clover is high in protein and in ash, especially lime. These constituents make it exceptionally valuable for all growing stock and for dairy cattle. It contains about 7 times as much calcium as timothy hay and 70 times as much as corn grain.

An Excellent Soil Improver

For soil improvement sweet clover is a crop par excellence. It makes a greater growth during the two seasons of its life than clover or alfalfa will make in the same length of time. During the second season, it develops a branching, fleshy root that penetrates the subsoil to a depth of at least 3 feet. When these roots die they naturally leave the subsoil porous, greatly improving the drainage and effectively deepening the soil for other crops. This is one of the most valuable effects of the crop for there is a large proportion of farm land that tile alone will not drain sufficiently. Farm land develops this impervious condition of the subsoil more and more the longer it is cropped with the ordinary shallow rooted crops. What has been attempted by the use of the subsoil plow and of dynamite is more effectively accomplished by sweet clover roots.

Sweet clover is easily inoculated and carries an abundance of nodules. Because of this fact and its rank growth it is probably the most effective gatherer of atmospheric nitrogen that we have.

Unlike most other clovers this crop does not require organic matter in the soil to give it a start. It asks only mineral matter, inoculation, and a hard seedbed. The manner in which it grows on excavated lands or in the bottom of a stone quarry is testimony to this fact. It is, therefore, the crop first suited to the poorest soils, provided lime and phosphorus are supplied. It will grow on fairly wet land and has been called by some "swamp alfalfa." The mellow, friable condition of a soil where sweet clover sod has been plowed under is always a revelation to those who try it for the first time.

Seeding Sweet Clover

The method of seeding sweet clover is not particularly different than for red clover or alfalfa excepting that it is more particular about having a compact seedbed. It will, in fact, do better in a hard road or on a subsoil than on recently plowed land. It should be grown in a regular rotation seeded with grain in the spring. On wheat or rye ground it can be sown in the late fall or winter and allowed to freeze in. But better results will usually be obtained by putting it in with a disc drill early in the spring. The ordinary disc grain drill is satisfactory if there is connection between the grass seeder attachment and hose. In this way from 6 to 8 pounds of scarified seed per acre is sufficient, for it is all covered and at the right depth, ¼ to 1 inch deep. When seeding is to be made with spring grain the land should be fall plowed, which is also

better for the grain. It is best to put the grain in separately, then roll the ground and go over it again with the drill for the clover seed alone. When any clover or grass seeding is to be made with grain it is wise to make no heavier seeding of grain than necessary for a good crop. For example, 1½ bushels of wheat per acre ordinarily gives so nearly a maximum crop, that, for the sake of the clover seeding, it may not pay to seed any more heavily.

Sweet clover may be seeded on run out meadows or pastures by scratching them over a little with the harrow in late fall and sowing the seed in winter. If the sod is not too heavy the seed may be put in with a disc drill in the spring with no previous harrowing. If stock is kept off the land until early summer, it will be ready for pasture.

Where soil is acid it is essential to lime before seeding sweet clover. Also, if this crop or alfalfa has not previously been grown on the field in question, inoculation must be made. Probably the simplest and least expensive way to inoculate is by the use of commercial cultures applied to the seed. Most of these cultures put out in the last few years have been found reliable.

Sweet Clover A Weed?

A valuable weed is not a bad name to apply to sweet clover. How often farmers have wished that the crop they try to grow were as hardy and persistent as some weeds. In sweet clover we have just

that combination, an extremely valuable crop with all the hardiness of a boisterous, arrogant weed. It defies drouth and wet. It grows on all kinds and conditions of soils, if they are not acid. After surprising, baffling, even disgusting some with its actions, it turns out to be a wonderfully valuable crop. It takes its mineral food from stones and the depths of the subsoil, and reaches into the air for its nitrogen. Finally, it leaves the plant food it has gathered in the soil in available form for other less hardy crops.

"Red Clover Is a Wonderful Plant."

RED CLOVER

NOVEMBER — NO. 6

As an average for the last ten years (1909-18), Ohio has had practically ten million acres of land under cultivation, of which less than one million has been devoted to clover or other legumes. These statistics indicate that the average rotation in Ohio is nine years of corn, oats, wheat, timothy and other non-legumes to one year of clover, alfalfa, sweet clover, or soybeans. In some sections of the state clover is now grown regularly every third year. Occasionally a man is found who practices the corn, soybean, wheat, clover rotation—a legume every second year. On entirely too many farms there are no fields of any of the legumes to be seen. The state of Ohio will never be able to produce the crops and livestock or livestock products she should, until the present acreage of legumes is at least doubled. As time goes on we can expect to see it trebled. There is plenty of opportunity for increased acreage of all the legumes, not the least of which is the old stand-by—red clover.

For those who have been reared in the Miami valley of Ohio, where red clover abounds and is at its best, it is difficult to believe that any other

Red Clover Not Confined to Limestone Soils

legume can successfully compete with red clover on the average well-managed farm in western Ohio. But red clover is not confined to this section of the state. The excellent fields of this legume to be seen at the Wayne, Cuyahoga, and Trumbull County Experimental Farms and on numerous other farms in eastern Ohio, under systematic soil treatment, confirm the belief that the successful growing of red clover is easily possible in any section of the state.

Red Clover a Wonderful Plant

Several years ago Mr. C. G. Williams, addressing an audience of farmers in Wayne County on the growing of red clover, voiced his sentiments concerning this crop in the above-mentioned statement. Mr. Williams is not given to exaggeration. His farming experience has been confined mostly to the non-limestone soils of Ohio. Yet in spite of his experiences on these soils he is an enthusiast on red clover.

If we examine into the literature on the subject, we find that less is written about red clover than about any other of the legumes mentioned. This may be because no one questions the importance of this plant. It may also be due to the fact that the importance of alfalfa, sweet clover, and soybeans has been emphasized until many men have concluded that red clover is grown only as a temporary substitute for these supposedly more desirable legumes.

Alsike a Strong Competitor

It would be interesting to know just what exact evidence we have in favor of red clover. It must be agreed that the comparative evidence between red clover and other legumes is of a very general nature and rests largely in the unrecorded experiences of many farmers. Each of the legumes has its enthusiasts and rightly so. Conditions differ, soils differ, men differ, and systems of farming differ. Under certain conditions red clover might suffer by comparison. Notable examples of this can be found in many fields on which a mixture of red and alsike clover seed has been sown on soils more favorable to the alsike than to the red clover. The result has been that these fields are covered with alsike, and very little red clover is to be seen. This might be construed as an argument against red clover, but there are many observing farmers who believe that such a happening is conclusive proof that something is wrong with the soil. It must certainly be agreed that alsike clover is better than no clover and some men even prefer it to red clover. But when alsike wins out in the soil in competition with red clover the soil is under suspicion.

Some Favorable Red Clover Evidence

Twenty-five years ago Director Thorne began his experimental work in soils on the Wooster farm. After some years of careful investigation he came to the conclusion that limestone and phosphorus were absolutely essential for maxi-

mum yields on this soil. He decided to demonstrate the results of his experiments in a large way. Accordingly four 10-acre fields were set aside for a rotation of corn, oats, wheat and clover. The fertilization consisted in the application of 10 tons of fresh manure reinforced with 400 pounds of acid phosphate and plowed under for corn, followed by 300 pounds of acid phosphate on the wheat. In unfavorable seasons from 30 to 50 pounds of nitrate of soda were used as a top dressing in the spring on the wheat. Two tons of limestone were harrowed into the soil before planting the corn. As a result of this treatment, the soil, which was originally thin, has been built up until the average yield for the last 12 years has been 78 bushels of corn, 65 bushels of oats, 35 bushels of wheat and 3 tons of clover hay per acre.

The question might be raised, what would the yields have been if soybeans, alfalfa, or sweet clover had replaced the red clover in the rotation? We do not know. But from what statistics show concerning the average yields of corn, oats, and wheat in Ohio, we feel reasonably well satisfied with those secured under this system of management.

The number of seeds in a bushel of clover seed has been carefully estimated. From these estimates it has been found that the usual sowing of

8 pounds per acre is sufficient to supply 50 red clover seeds per square foot of soil. Does anyone believe that 50 plants per square foot are required to produce a satisfactory stand of clover? On the contrary, four or five plants would undoubtedly be sufficient for what would be considered a perfect stand. The chief reason why we sow such large amounts of seed is because experience has shown that oftentimes the stand of clover is thin even with this amount of seed. Undoubtedly part of the difficulty lies in poor seed. But this fails to explain the whole trouble. Evidently in many soils the conditions are so unfavorable for the young clover plants that they are not able to survive. The direct cause of the death of many may be the bacterial and fungous diseases which lie in wait for them in the soil. But it is a well-known fact that the more vigorous the plant the better able it is to withstand the attacks of these parasites. The vigor of plants is closely associated with the supply and balance of the available plant food elements in the soil. The ravages of drouth are also much smaller on soils in a high state of productivity.

High Infant Mortality Among Clover Plants

The method of seeding clover varies considerably. Some farmers make use of special seeding machinery, disk drills or harrows after the ground has dried out sufficiently in the spring to permit of their use. Others practice seeding early enough

Seeding Practices Differ

in the spring to take advantage of the frost as a covering agent. In some cases seeding is deferred until the cracks have opened up in the soil into which some of the seed fall and germinate. Quite a few farmers practice seeding twice, half of the seed being applied during the freezing and thawing period and the remainder later. Some farmers apply from 150 to 200 pounds of acid phosphate with a disk drill at the time of seeding.

It is a common practice to sow a mixture of red clover, alsike clover and alfalfa at the rate of 5 or 6 pounds of red clover, 1 to 3 pounds of alsike clover and from 1 to 2 pounds of alfalfa per acre. In all such cases it is hoped that the alfalfa and red clover will comprise the major portion of the crop, while the alsike is sown as insurance against failure. Fields so sown frequently show mostly alsike with an occasional patch of red clover and at infrequent intervals a stalk of alfalfa. Alsike clover is growing in popularity. The reason is apparent. We wonder whether this is a favorable sign for the best interests of the agriculture of Ohio.

Why Red Clover Fails

It is well to keep in mind that red clover is not a crop which can be used to advantage on poor soils. Red clover will not grow on worn-out soils. The soil must be supplied with plenty of available plant food for satisfactory crops of clover in just

the same way as for large yields of corn, oats, and wheat. The use of acid phosphate on the wheat is not only for the benefit of the wheat, but is especially necessary for the clover crop following.

Red clover is a plant which can be used to best advantage in keeping good soils good. As long as this crop is being grown successfully, the soil is in good condition for the growth of most of the other desirable farm crops. When red clover fails, it is time to remedy the conditions which prevent its growth. Acid phosphate and limestone are two very effective remedies for red clover failures. It is a waste of time and money to throw away red clover seed on a poor soil which has not been supplied with these very essential materials.

Red Clover Needs Encouragement

It is not our purpose to discourage the growing of other legumes. We need and will grow vastly larger acreages of alfalfa, soybeans, and sweet clover. There is plenty of space for all of these. But red clover needs our encouragement. It is the only crop in the ordinary rotation which has any especial merit as a soil improver. The organisms which live in the nodules on its roots are constantly at work taking nitrogen from the air and storing it up for succeeding crops. The manure produced from feeding red clover has a distinctly higher value for fertilizing purposes than that resulting from the feeding of timothy and

weeds, the usual substitute for clover. Red clover is worthy of our best efforts. We will find red clover coming into its own as soon as the fertility of the soil has been increased sufficiently to give it a fair chance.

A Little Alsike Helps the Clover Mixture.

ALSIKE CLOVER

DECEMBER—No. 7

"Because of the many good qualities of this clover it is deservedly a favorite wherever it can be successfully grown." The foregoing is what Shaw in his book on Clover has to say concerning alsike clover. Continuing, he says, "It is even more hardy than medium red clover in the sense of enduring cold and will live under conditions of climate so austere as to be fatal to red clover. The best climatic conditions for growing it are found not far from the boundary line between Canada and the United States and in the vicinity of the Atlantic Ocean and the Great Lakes."

Piper says, "Alsike clover has been growing in importance in America in recent years mainly because it succeeds well on land that will no longer grow red clover on account of 'clover sickness.' Apart from this it is valuable for growing on land too wet for red clover." He might have added, "also on land too acid for red clover."

There are several reasons why alsike clover is of particular importance in Ohio. First, the climatic conditions are suitable; second, there are large areas of wet and acid soils where red clover

does not thrive; and third, there are other areas where red clover is more or less of a failure because of clover diseases.

Alsike Often Makes Large Growth

Since the introduction of alsike clover into the United States it has had to meet the competition of medium red and mammoth clover. Observations of the three crops have favored the general impression that the alsike is the least valuable of the three. This is because it usually is assumed that the value of a legume crop for soil improvement is proportional to the yield secured. While it probably is true that the yield (and therefore the organic matter produced and nitrogen fixed) is greater in a good growth of medium red or mammoth clover than it is in alsike, yet undoubtedly there are conditions where the reverse is true. At any rate, it is known that in many cases very satisfactory yields are obtained from alsike clover. Because of its procumbent growth it is probable that the yield of alsike clover is underestimated unless actual weights are secured. A Michigan farmer reported that on his rich underdrained soil alsike clover grew to a height of 3½ feet, gave three cuttings and produced 4 tons of hay per acre. Mr. Archie Newcomb reports cutting three crops of alsike clover in one season from an old swale in Geauga County. Mr. H. P. Miller says he sows red clover on his high ground, but that he prefers alsike for the lower lying areas which

naturally are not as well drained. Many more instances might be given as proof that alsike clover gives good yields on soils that are not in proper condition for red clover and alfalfa.

Alsike Valuable for Soil Improvement

Even grown under the same conditions, the yields of aslike sometimes correspond very favorably to those secured from other common legumes. The Indiana Station made seedings of alsike, red clover and alfalfa at intervals of one month during the summer of 1898. In 1899 the season was favorable and two cuttings were secured in each case. The results are indicated in the following table:

Yield of Alsike Clover — Indiana Station

Time of Sowing	Red Clover	Alsike Clover	Alfalfa
April 15	8400	7800	0
May 15	7480	7000	2800
June 15	5920	6000	2800
July 15	2200	2400	3800
August 15	1440	3200	5200
September 15	0	0	0

Some data presented by the Pennsylvania Experiment Station are interesting, not only as offering a comparison of alsike and red clover, but also as indicating the high value that either one has for soil improvement purposes. Several legumes were sown on April 30, 1896, and harvested during

the next 18 months as they matured. Root weights were determined to a depth of 2 feet.

Comparing Alsike With Other Legumes — Pennsylvania Station

Crop	Yield of hay	Nitrogen	Equal to Sodium Nitrate	Value of Nitrogen
	Lbs.	Lbs.	Lbs.	
Canada field pea				
Tops	3937	108	675	$32.40
Roots	281	7	41	2.10
Hairy vetch				
Tops	2492	74	464	22.20
Roots	231	4½	28	1.35
Red clover				
Tops	4804	92	572	27.60
Roots	2630	52	326	15.60
Alsike clover				
Tops	3956	86	535	25.80
Roots	1954	34	214	10.20

These data are not given for the purpose of attempting to prove that alsike clover yields more heavily than alfalfa and red clover, as numerous other data can be offered in refutation of such a claim. Rather they are offered for a double purpose, first, to show that in some cases alsike clover has compared well with red clover; and second, to raise the question whether better cultural methods might not tend to remove the principal objection to it, i e. low yields.

Altho alsike clover will make a fair growth on poor soils, it responds to good treatment. What-

ever may be said in regard to the efficacy of phosphorus and limestone in increasing red clover applies with equal force to alsike clover. In a recent issue of *The Rural New Yorker* (1918), Mr. George W. Dell of Tioga county, discussing the cheap hill farms of New York, wrote "All of our land needs lime, and fields that have been limed and otherwise well treated grow as good and as large clover as can be found anywhere. I saw alsike clover on one of these farms last year that was over 4 feet long and yielded 3 tons to the acre."

Alsike Needs Phosphorus and Lime

Because of the effect on the subsoil, the root system of a legume crop is of considerable importance. At the Minnesota Experiment Station it was found that at 1 month of age the main root of alsike extended 9 inches into the soil and at 2 months it had reached a depth of over 2 feet. Its early penetration was somewhat more rapid than that of red clover roots, altho the latter finally extended considerably deeper.

Alsike Has a Fair Root System

During the past 10 years, difficulty in growing clover has been reported from several areas in Ohio where formerly it grew luxuriantly. In certain cases clover anthracnose has been shown to be the cause. The Tennessee Experiment Station has this to say concerning this disease. "A thoro field survey had shown that clover dies on every variety of soil existing in the state (Tennessee)

Alsike Not Affected by Clover Anthracnose

and under almost every conceivable method of cultivation. * * * The disease (anthracnose) was found in almost every clover field visited, and seems to exist in its severest form in the oldest and best farming sections of Tennessee. While beyond a doubt other clover diseases than those thus far found will eventually come to light in the state, and may prove to be of considerable importance, there remains little doubt that the one here discussed is far more responsible for the failure of the clover crop than any other disease or soil condition." As early as 1910 Selby reported this disease as attacking clover and alfalfa in Ohio. During the past year Van Pelt of the Ohio Experiment Station made a survey of Ohio and showed the seriousness of this disease and also of root rot as menacing the success of red clover. For control measures he suggests, "The absence of red clover from such diseased fields for a period of 3 or 4 years, together with deep plowing of the old diseased sod, should tend to reduce infection on another crop. Another phase of the control measures is to be urged and that is to replace the red clover with alsike clover or white sweet clover. Where soils are of a slightly acid nature most farmers are sowing the alsike clover. It makes a much better growth on such soil, and besides it is resistant to the above mentioned diseases."

Red Clover, Alsike, Alfalfa and Timothy Make a Good Mixture

Red clover is desirable, but uncertain on many soils, particularly those that are acid. On such soil alsike is much more certain, altho usually less desirable from the standpoint of yield. The two, however, because of their characteristics, make a good combination. Should conditions be favorable for the development of red clover, the alsike offers no interference, but in case of a partial or entire failure of red clover, the alsike usually makes a fair crop. Mixing alsike seed with that of red clover is thus a partial insurance against clover failure over a large part of Ohio. Mixing with red clover, timothy and alfalfa is beneficial also from the standpoint of the alsike, as these upright growing plants tend to support the more spreading alsike. The timothy, if sown in the spring, does not interfere with the growth of clover. Instead, it increases the yield of hay by filling in where the clover is thin. In addition it makes a better sod to plow under. A mixture that can be recommended is 6 pounds of red clover, 3 pounds of alsike, 4 pounds of timothy and 1 or 2 pounds of alfalfa.

Alsike a Danger Signal

It is because of its adaptation to acid soils that alsike clover often is regarded more or less as a danger signal. Its growth may represent a step down from red clover culture, and unless the practices which made this necessary are checked, another step eventually is taken, and this one leads

to timothy and red top with the elimination of all legumes. For this reason, if for no other, one should not be entirely satisfied with alsike clover, but should continually strive to keep the soil in condition to grow something a little higher in the scale of legumes.

Alfalfa Requires a Good Soil and a Good Farmer.

ALFALFA

JANUARY — NO. 8

The maximum acreage of alfalfa in Ohio for any one year has so far not exceeded 80,000 acres or an average of less than 1000 acres per county. The slow extension of this important crop is, we believe, mainly because but few farmers have yet learned to adapt it to a rotation. The idea still prevails that it means the loss of one year's cropping on a field to get alfalfa started. Once a stand is secured the owner hesitates to plow it up. But alfalfa can be sown with a grain crop in the spring as well as clover or timothy, and the oftener an alfalfa sod is turned under the better for the farm and the farmer.

Alfalfa in Rotation

Men who have had experience in growing alfalfa in rotation are confident that it is entirely possible, practical, and profitable to grow it in these or in other similar rotations.

Corn, oats, alfalfa, alfalfa.

Potatoes, wheat, alfalfa, alfalfa.

Tobacco, wheat, alfalfa, alfalfa.

Progressive farmers are to be found in nearly every county of this state who have adopted such rotations and have gotten entirely away from the

practice of summer fallowing to get alfalfa started. Many farms can be found where this system is under way and where the landowners are enthusiastic in their testimony. Plowed down at the end of 2½ or 3 years from seeding, it does the soil approximately as much good as a sod of longer standing and plows without so much difficulty.

Seeding Alfalfa

Seeded with wheat in the spring, alfalfa is best put in with a disk drill at the rate of about 10 pounds per acre as early as the ground can be worked. In this way the seed is all covered at about the right depth, ½ to 1 inch, and it comes up at the right time to get a good start. The ordinary disk grain drill is entirely satisfactory, if there is connection between the grass seed attachment and hose of the drill.

When alfalfa is seeded with spring grain, it is important to have a compact seedbed. This usually means fall plowing, which is also best for the grain crop. It will pay well to drill in the grain by itself, then roll or drag the ground and go over again with the drill for the alfalfa seed alone.

It is doubtful whether it pays to seed any grain crop as heavily as will give the maximum yield when either alfalfa, clover, or grass is to be sown in the grain. A heavy rate of seeding means very little more grain per acre than a medium rate, and endangers the hay crop. For example, in the rate-of-seeding wheat experiment at Wooster, the 19-

year average net yields of wheat have been 28½ bushels and 28 bushels from a 2-bushel and a 6-peck seeding respectively.

If weeds come up badly after grain is cut they may be clipped once in August, but the alfalfa should not be cut the year of seeding. Instances are common where cutting the first year's crop in September has killed it.

Alfalfa for Soil Improvement

Where a legume crop is to occupy the land 2 years after the seeding year there is none which will at the end of this time leave so much in the way of roots and stubble to plow under, nor during the period produce so much feed as alfalfa. In a 4-year rotation the residues from the alfalfa crop will furnish more than enough nitrogen for the following cultivated crop, and the manure produced from feeding the alfalfa harvested will supply more than enough for the second crop in the rotation, allowing in each case for the nitrogen lost in drainage. If the rotation is lengthened by allowing alfalfa to remain another year, more nitrogen will be accumulated in proportion to the hay produced, but it is doubtful whether after the second year the roots and stubble furnish any additional nitrogen for plowing under.

In a shorter rotation, where the hay crop is to occupy but 1 year, sweet clover, mammoth, red, or alsike are probably better for soil improvement than alfalfa, and may in that time yield as much

or more than alfalfa. It takes alfalfa 2 years from seeding to get its stride, at which time biennials are dropping out.

Alfalfa, or the clovers just mentioned, do not form a very close sod and do not fill the surface soil with fibrous roots so effective in giving tilth to cultivated land. For this reason a light mixture of timothy or other grasses may even increase the value of these legumes for soil improvement, but the grass must not be allowed to interfere too much with the growth of the legume.

The deep root system of alfalfa is the second basis for its claim to high rank as a soil improver. The need of a deep-rooted crop in the rotation has not been sufficiently appreciated or acted upon in the program of soil improvement for the great majority of Ohio soils. Alfalfa and sweet clover have no equals in this respect. Whenever they are plowed under the subsoil is left full of decaying roots which render it porous, thereby greatly improving the drainage and encouraging a deeper feeding range for other crops. Then, too, they bring up mineral plant food and leave it to enrich the surface soil. The efficiency of tile drains may be more than doubled by the cooperation of these crops. Rolling land, supposed to need tiling, can often be taken care of by these deep-rooted crops alone.

"Alfalfa requires a good soil and a good farmer, but enriches both." It is true that alfalfa is naturally adapted only to fertile, well drained soils containing lime carbonate, and something approximating this condition should usually be assured before making an attempt to grow it. The main reason alfalfa does not succeed well on poorly drained land is that it heaves out of the ground during winter or early spring. It is commonly supposed that the ground must be well supplied with organic matter to grow alfalfa, and to this end a green-manure crop is sometimes plowed under in preparation for seeding. But, if the soil is well limed and phosphated, and care is taken to insure inoculation, alfalfa may succeed even on light colored lands that are below the average in fertility. Mineral matter, inoculation, and a foothold are the prime requirements of alfalfa. Given these, there is scarcely any excuse for growing the less valuable timothy crop in its stead. This point was illustrated in the experimental growing of alfalfa and timothy in comparison on the light colored soils of southern New York. These soils are very acid. Limestone was supplied at the rate of 5 tons, acid phosphate 500 pounds, and muriate of potash 100 pounds per acre. The following data were obtained:

Soil Conditions for Alfalfa

Yield Per Acre On Hill Lands of New York

Year	Timothy Lb.	Alfalfa Lb.
1915	2870	3820
1916	2410	8800
Total	5280	12620

In this experiment alfalfa and timothy were each sown without a nurse crop in April, 1915, and in each case a good stand was secured. Apparently, therefore, even on land of this type, it would seem more rational to supply the conditions required by alfalfa and grow it rather than timothy.

But much of such hill land has a rather impervious subsoil and is poorly drained. Sweet clover, then, may well be the forerunner for alfalfa. And in addition to loosening the subsoil it will provide inoculation which, on these soils, is more easily accomplished for sweet clover than for alfalfa. Generally this is a good rule to follow.

Preparing acid soils for alfalfa requires more lime than for the clovers. It seems advisable to lime both sides of the furrow. This, in practice, usually means waiting for the second application of lime, made regularly once in a rotation, before seeding alfalfa.

Attempting to seed alfalfa on recently plowed land is risky. It requires a more compact seedbed

than is usually obtained in this way. Some plow a wheat stubble and seed in August, but the odds are against this practice. Even if the ground is worked down sufficiently and the weather is right, there is still a long chance that the crop will not get enough growth to carry it thru the winter in good condition .

Feeding Value of Alfalfa

A conservative estimate of the yield of alfalfa in rotation on good land would be 4 tons per acre per year. On this basis the following table will give some comparison of the feeding values of alfalfa and other crops.

Comparative Feeding Values of Crops

Crop	Yield per acre	Value per acre	Digestible Protein Pounds	Digestible Nutrients Pounds
Alfalfa	4 tons	$100	850	4130
Sweet clover...	3 tons	60	650	3040
Red clover....	3 tons	60	456	3050
Timothy	2½ tons	60	150	2430
Corn	75 bu.	75	315	3600
Barley	50 bu.	50	216	1900
Oats	75 bu.	45	232	1690
Wheat	35 bu.	70	183	1670

The high feeding value of the alfalfa crop, as indicated in these figures, is further increased when we take into account the large amount of mineral matter, especially calcium, magnesium, and phosphorus, which it contains. The quality and palat-

ability is better than that of almost any other roughage.

Considering the very outstanding merits of alfalfa, both for feed and soil improvement, the extension of its acreage offers one of the greatest opportunities for improvement in Ohio agriculture.

Top Dressing Benefits Both Wheat and Corn.

TOP DRESSING WHEAT

FEBRUARY — NO. 9

From a maximum of 3,000,000 acres in 1899, the area devoted to wheat in Ohio fell to only a little over 1,500,000 acres in the years just preceding the European War. There has been considerable discussion among the farmers as to the profitableness of this crop. Many of them said that were it not for the fact that the growing of wheat affords the most convenient means of seeding to clover, they would not include it in the rotation. It seems desirable, therefore, to consider the wheat crop not only as to the number of bushels of grain produced but also in its relation to the stand of clover which is desired the following year.

Straw a Valuable By-Product

For every bushel of wheat produced there will be, on the average, 100 pounds of straw. Some farmers grow more acres of wheat than they would except for the purpose of having sufficient straw for bedding. In other cases, the straw is sold. It seems questionable whether the latter policy is the most profitable one. Several years ago Mr. C. G. Williams began experimenting on the value of straw as a top dressing on wheat. One of the

most interesting sights on the Wooster farm during the fall of the year is the series of plots, to a part of which, straw has been applied as a mulch. As far off as the field can be seen the effect of the straw in producing a most luxuriant stand of clover is evident. Not only has the clover been very much improved by the straw, but the yield of wheat has been increased several bushels. Applications of more than 1 ton of straw per acre were favorable to the clover, but had a tendency to decrease the yield of wheat.

Limestone —Better Now Than Never

Of course, it must be agreed that limestone has a greater opportunity to become effective when it is applied to the soil immediately after it has been plowed for corn. The limestone and soil are thoroly mixed during the preparation of the soil and in the cultivation which follows. This same distribution is accomplished almost as effectively by applying the limestone to the soil before it is prepared for wheat. But failure to make the application in both cases does not argue in favor of waiting until the corn crop again appears in the rotation. Good intentions are not to be trifled with. They should be acted upon before they are forgotten. Wheat is benefited by limestone even tho it is applied in the spring on the growing crop. But more than this, the young clover plants are dependent on a supply of this material, and failure to apply the limestone at this time may

be most costly. A good crop of clover is ample reward for an application of 1 or 2 tons of limestone.

Clover Needs More than Limestone

The opinion is quite widespread that an application of limestone insures a crop of clover. However, it must be remembered that clover will not grow on poor soils any more readily than will corn or wheat. Clover requires considerable amounts of both phosphorus and potash in available forms before it can begin to function as a nitrogen-gathering agency. One of the chief reasons for clover failures is the absence of sufficient available plant food, including nitrogen, to give the young clover plants a vigorous start. A considerable part of the good effect of straw on clover seedings may be accounted for in the plant food materials which are leached out of the straw by the spring rains. This, in addition to affording a more convenient cover for the clover seeds, must explain most of the benefit. If the acid phosphate which was needed was not applied the previous fall on the soil as it was being prepared for wheat, there is every reason to believe that excellent results can still be secured by scattering it over the wheat in the spring of the year.

A Little Manure Goes a Long Way

When one considers that a ton of good manure will contain as much nitrogen as 75 pounds of nitrate of soda, in addition to its content of soluble potassium, it seems strange that more men do not

make use of manure, at least on the thinner areas of the field, as a substitute. A 4-ton application of open yard manure at Wooster on thin soil, which received no acid phosphate, raised the yield of wheat as a 20-year average from 11 to 18 bushels. The following clover crops were increased from 1800 to 2900 pounds per acre. On limestone soil at the Pennsylvania Experiment Station 6 tons of open yard manure increased the yield of wheat from 13 to 23 bushels, and the clover from 2500 to 3900 pounds as a 35-year average. By filling the spreader only level full and covering only the thinner spots, a little manure will go a long way toward helping out the wheat and assuring a catch of clover.

Nitrate of Soda Effective but Expensive

There is no doubt as to the efficacy of nitrate of soda in increasing the yield of wheat on many soils. Occasionally decreased yields follow its use, due perhaps to a lack of other elements to supplement the nitrogen. Taking all the experimental evidence into consideration, however, throws doubt on the profitableness of its use. On the 12 experimental farms in Ohio, 3 bushels of wheat have been produced for every 100 pounds of nitrate of soda when used at rates of from 45 to 160 pounds per acre. In all these experiments acid phosphate and muriate of potash had been applied at an average of 150 pounds of the former and 50 pounds of the latter. The cost of nitrate of

soda and the selling price of wheat will determine whether nitrate of soda can be used at a profit. At present the margin of profit is small.

The Question of Relative Profits

Averages from experimental data sometimes mean little to the individual farmer. His is a specific case in which a soil of a particular type has been previously treated in a certain definite, or perhaps indefinite, way. If the average margin of profit is small it may be that in his case the identical treatment would result in a loss. Farmers have learned thru years of experience with wind and weather that the most alluring prospects sometimes dwindle into most distressing failures. Only the man who has taken advantage of all the better investments in fertility is justified in taking the risk involved in a narrow margin of profit. The question for decision may be, therefore, between nitrate of soda on wheat or more acid phosphate either as a spring application on wheat or for the corn crop to be planted the same season. Many farmers will answer this question by buying more acid phosphate. It seems desirable to point out that, as a rule, the application of acid phosphate to the wheat in the fall is only sufficient for the needs of the wheat and not for the one or more crops which may follow before any additional phosphorus is supplied. If the rotation is corn, oats, wheat, and clover, experimental evidence indicates that 400 pounds of acid phosphate should

be applied either to the wheat in the fall or this amount made up by a supplemental addition in the spring at the time of clover seeding, before the use of nitrate of soda at present prices ($100 per ton) can be justified. If alfalfa follows the wheat, the application of acid phosphate might well be at the rate of 200 pounds per acre for each year until the ground is to be again plowed for corn. This acid phosphate may as well be applied to the wheat as a matter of convenience.

Sulphate of Ammonia Doubtful

It seems necessary to add that sulphate of ammonia can be used as a satisfactory substitute for nitrate of soda on many crops. So long as the soil contains a sufficient amount of limestone its use can be expected to give as good or better results than nitrate of soda. Yet, it seems a doubtful policy to apply sulphate of ammonia as a top dressing for wheat. The margin of safety against clover failures on many farms is so small that the use of sulphate of ammonia may be sufficient to overcome it. Clover failures are expensive.

Playing Safe on a Clover Catch

We recognize that wet soils should be drained, that acid soils should be limed, and that most soils respond to liberal applications of acid phosphate. The ideal which the successful farmer sets before himself is that of growing 50 bushels of wheat and corresponding yields of other crops. All factors which serve to limit the productive capacity of the soil must be taken into consideration. But the

capital available and the economcial use of labor have not always made it possible for farmers to live up to their ideals. Wet spots still exist, even in fields systematically drained. Acid spots develop in soils which are full of limestone. The money which should have been used for acid phosphate was required perhaps to pay the doctor's bill. Unless we are sure of the soil it is best to play safe in clover seeding. We recommend again 5 or 6 pounds of red clover, 3 pounds of alsike, 3 or 4 pounds of timothy and perhaps 1 to 2 pounds of alfalfa. With liberal applications of limestone and acid phosphate, with perhaps the additional advantage of a top dressing of straw, manure, or nitrate of soda, the red clover should win out in the competition. If it fails, alsike and timothy make acceptable substitutes.

Clover Shares the Cost

In a recent voting contest conducted by the Independent Magazine, red clover ran a neck-and-neck race with the columbine and the goldenrod for the honor of being the national flower. Contrast with this the action of a member of the Illinois State legislature in introducing a bill making it compulsory for every farmer to seed a certain percentage of his acres in clover every year. Not only is it now recognized that clover plays a very essential part in the permanent soil building program, but it is a well known fact that the success of its growth is an excellent index of the state

of productivity of the soil on which it is grown. The cost of acid phosphate, limestone and manure cannot be charged entirely to the wheat, but a part of this cost must be borne by the clover crop which follows. The value of the clover crop justifies this.

Eliminating Weeds from the Competition.

MORE AND BETTER CORN

MARCH — NO. 10

No crop occupies so prominent a position in Ohio agriculture as corn. Of the 10 million acres of land under cultivation in the state more than 3 million are devoted to this crop. It deserves our especial attention not only because of its acreage but also, and more particularly, because it is the starting point at which systematic efforts in soil improvement may well be begun.

The growing of corn affords an opportunity to make use of large amounts of coarse manure. Its cultivation has all the advantages to be derived from fallowing with none of the disadvantages. Limestone applied on this crop not only benefits the corn directly, but becomes so intimately a part of the soil as to make it most effective for the other crops following. Each time corn appears in the rotation it provides this same opportunity for a step upward in soil improvement.

Heavy Sods Mean High Yields

Good corn is grown most easily in short rotations. The crop revels in organic matter. In no way can this be supplied better than thru the turning down of heavy sods. Perhaps the greatest evil of a long rotation is the thinning of the sod

that is bound to occur unless special precautions are taken to prevent it. Why not prevent it? Manure, fertilizer and lime, which are remarkably effective in producing large hay crops, make this possible. Were this fact better appreciated, preparations for the corn crop this year would have been begun the last time corn was grown in the rotation. With the idea of better sods in mind, more limestone would be supplied, the cereal grains would be more liberally fertilized with phosphorus, and a greater use would be made of manure as a top dressing. Following such practices clover failures are eliminated. The result would be heavier sods to plow under for corn. Too often there is some hesitation to sacrificing a thick sod which gives promise of yielding another heavy hay crop. Such a policy is short sighted and is not conducive in the long run to the largest yields of either corn or hay. If for any reason a field remains in grass for more than one year the sod should be kept in good condition by an annual top dressing of manure or an application of acid phosphate and nitrate of soda. Sods resulting from such practice, altho inferior to leguminous ones, usually produce very satisfactory corn crops.

Clover Sod or Manure Indispensable

A hundred-bushel corn crop with the stover requires 150 pounds of nitrogen. A yellow color of the growing crop indicates that insufficient quantities of this element have been provided. Over

some of the factors which determine nitrogen supply the farmer has no control. Providence determines when it shall rain and whether the days and nights of June are to be hot or cool; but over other factors the farmer is master. He determines the place in the rotation, the amount of manure available for use, and the physical condition of the soil as well as its lime and phosphorus content. At the Ohio Experiment Station corn has produced 29 bushels following timothy in a 5-year rotation as compared with 35 bushels after clover in a 3-year rotation. The use of 8 tons of manure on the clover sod has increased the yield to 60 bushels. Experiments indicate that the grain farmer can plow under his stover, straw, and clover with results which are practically as good as those secured by feeding the crops and returning the manure. The good effects of clover and manure can be explained very largely by their ability to supply nitrogen in amounts sufficient to satisfy the requirements of the growing corn. When it is considered that a large acreage of corn is grown in rotations that are longer than 5 years and that an additional acreage receives little or no manure it is not surprising that many poor crops should result. The system under which they are grown does not supply sufficient nitrogen for large yields. The use of nitrate of soda may help but, in general, to meet this deficiency with com-

mercial nitrogen is well nigh an economic impossibility and should not be attempted.

"A Stitch in Time Saves Nine"

No other crop responds better to good tilth than corn. Good tilth has reference to the ease with which the soil may be put in shape to grow corn. Its being a characteristic of the soil is determined by what has gone on in previous years. The poorer the tilth the more necessary it is to use greater care in the preparation of a good seedbed. Such a seedbed is mellow and free from clods and air spaces that may cut off capillary moisture from below. Early plowing, to allow a few weeks for the soil to settle and reestablish capillary connections between the subsoil and seedbed, helps. With later plowing it is desirable to work the soil immediately after the furrow has been turned to prevent undue drying. Clods allowed to form at this time may persist during the greater part of the summer. Covering them with an inch or two of fine earth does not materially lessen the injury they may cause. With very late plowing it is often desirable to precede the plow a few days with a disk or cutaway harrow. This is particularly true when there is a tendency for the soil to turn over hard and lumpy. A sharp disk and plenty of power is the remedy. Were one assured that rains would be plentiful and well timed during the growing season such precautions would be unnecessary. It is better to err on the

side of safety and prepare for a dry period. If the rains come, no harm has been done and if they fail, the proper kind of a seedbed is the best insurance against failure.

Early Applications of Manure Most Effective

Manure produces more corn if applied considerably in advance of planting. At the Maryland Experiment Station spring applications of manure produced only 58 bushels of corn as compared with 69 bushels from the same amount applied the preceding November and 83 bushels when spread during the month of August. Hauling manure consistently throuout the fall and winter has many advantages. Corn yields are increased by this practice and the loss of plant food is reduced to a minimum. At the Ohio Experiment Station 8 tons of manure taken directly from the stable to the field has produced 60 bushels of corn, whereas the yield has been only 54 bushels when the 8 tons of manure have first been exposed to the weather for two or three months. Any delay before application means a loss.

Acid Phosphate Highly Profitable

There is no satisfactory substitute for acid phosphate. Manure will not take its place; neither will limestone. An application of from 300 to 500 pounds per acre is none too much. This may be applied with manure thruout the winter or drilled in the soil just prior to planting. The former method is economical of time and gives excellent results. A liberal use of acid phosphate means

corn that is more vigorous and thus less injured by disease and insect attacks. The use of acid phosphate causes a remarkable root growth that enables the crop better to withstand drouth. Finally, acid phosphate produces heavier ears of better matured corn. Merely adding 1 ounce to the weight of each ear increases the yield 7 bushels per acre. An application of 320 pounds of acid phosphate has not only increased the yield of corn grown on a well manured clover sod at Wooster by 7 bushels, but was responsible for an additional increase of 5 bushels of wheat and almost ½ ton of clover hay, as an average for 17 years.

Nitrate of Soda Helps

Corn does not grow luxuriantly until the soil becomes sufficiently warm for the rapid production of nitrates. Its early growth may be hastened by the application of nitrate of soda. This is to be encouraged in northern sections and on those soils, which because of poor drainage conditions, do not warm up rapidly in the spring. In such cases many good farmers are using nitrate of soda even on well manured clover sods. Those who follow the practice usually drill about 50 pounds in the row at the time corn is planted. It not only gives the advantage of a longer growing season but the more rapid growth of the corn permits earlier cultivation and thus better control of weeds. Mixing a little acid phosphate or bonemeal with the nitrate facilitates drilling.

Limestone Increases Corn Yields

On acid soils it is to be expected that the use of 2 tons of limestone per acre on corn will increase the yield from 3 to 12 bushels. In many cases the increase will pay for the cost of liming. The corn crop offers an excellent opportunity for the application of limestone. The time to begin preparations for a better crop of clover and for the sod which results from its growth is during the time when the soil is being fitted for corn. Locked up in the roots and stubble of this clover crop and in the manure produced from feeding it are the elements which the succeeding corn crop needs for the upward step in yield which must come with each succeeding rotation.

One Thousand Bushels of Shelled Corn on Ten Acres

Why not? Altho only a few men have grown this amount under contest conditions and have had their results certified by impartial judges, it is probable that many others have done as well but without leaving behind any authentic record. If yields of this character are merely the result of very fertile soils made so by overflow conditions or other natural advantages they mean little. A lesson of unquestioned value is that taught by Mr. Earl Johnson of Lake county who, in a rather unfavorable season (1917), grew 100 bushels of corn per acre over a large field on soil which 15 years before was said to be worn out. Limestone, acid phosphate, clover and manure did the trick. The lesson for those who are ambitious to achieve

such yields is to start 5, 10 or 15 years before the crop actually is grown. Under contest conditions, it perhaps is permissible that investments in fertility and time be stretched somewhat beyond the economic limits of ordinary field production. However, by keeping strictly within these limits many corn growers may find themselves "over the top" with 1000 bushels on 10 acres before their days in the corn field are past. It should be possible for fathers to do on 10 acres more than 10 times what their boys are doing on one acre.

Big Tops Mean Big Tubers.

FERTILIZING THE POTATO CROP

APRIL — NO. 11

The average yield per acre for potatoes in Ohio during the past 10 years (1909-18) has been 82 bushels. Soil, season, cultured methods, insect pests, diseases, and other factors combine to produce this comparatively low yield. Among these, soil conditions and soil treatment are of primary importance. Ohio may not be as fortunate in climate for potato growing as are certain other sections of the United States. Yet the normal rainfall, temperature, sunshine, and length of season in Ohio are sufficient to double or treble this yield, if the plant food materials are present in suitable form and amount. Both experience and experiment have shown that with a little attention to soil treatment it is entirely possible, practicable, and economical to produce 180 or more bushels of potatoes in the place of the 82 now grown on the average Ohio farm.

Clover Furnishes a Good Starting Point

Director Thorne has made the statement that "for the basis of a good crop of potatoes nothing is equal to a well drained clover sod." Potatoes like a loose, mellow seedbed. This is nicely furnished by the decaying clover roots. The growing

roots of the potato are enabled to extend more readily thru the soil, and the tubers are permitted to expand more easily in their growth. In addition, the clover residues will furnish a large supply of nitrogen in readily available form. If the sod is a heavy one or carries a considerable quantity of second growth, it will furnish also a considerable amount of potassium and phosphorus. These statements are well brought out in some work carried on by the Delaware Experiment Station in which it was shown that a 4-months-old red clover sod (entire plants) might contain as much as 103 pounds of nitrogen, 12 pounds of phosphorus and 45 pounds of potassium per acre. Of these amounts approximately one-third of the nitrogen and phosphorus, and one-fifth of the potassium was found in the clover roots. An older sod would carry a still larger root system and consequently still larger amounts of plant food materials.

In 1902 the Canadian Agricultural Experiment Station at Ottawa grew potatoes on land that had been in wheat, oats, and barley, both with and without an accompanying seeding of red clover the previous season. Where clover was seeded the entire growth of clover was turned under for the potatoes. Where no clover was seeded only the stubble of the preceding grain crop was plowed down. The yield of potatoes averaged 40 bushels better on the plots on which clover had been sown,

altho the land unassisted by clover produced over 350 bushels per acre.

Manure Helps Out on the Nitrogen and Potassium Supply

It is a curious fact that the recent war has aided the farmer in solving certain fertilizer problems in regard to the purchase of commercial materials which in normal times are frequently quite perplexing. This came about thru the forcible removal of potash salts from the market and thru a very considerable increase in the price of nitrogenous materials. In so far as the present year (1919) is concerned, commercial carriers of potassium seem likely to remain far above the point at which they can be used with profit on ordinary field crops. Commercial nitrogen also is questionable. Most farmers have discovered that the potato likes potassium and ordinarily responds well to applications of this element. The question naturally arises as to how the demands for this material can be met under present conditions. An answer may be found in stable manure. Here is an effective and economic carrier of both potassium and nitrogen. A ton of average farm manure will contain approximately 10 pounds of nitrogen, 2 pounds of phosphorus and 8 pounds of potassium. Thus a dressing of 10 tons of manure per acre on the clover sod during the late summer or early fall will carry about 100 pounds of nitrogen, 20 pounds of phosphorus and 80 pounds of potassium. This will serve to stimulate the clover sod and at

the same time will be largely carried forward to the potato crop and the crops following. At Wooster the 24-year average unfertilized yields of crops in a potato-wheat-clover rotation have been 132 bushels of potatoes, 26 bushels of wheat, and 3500 pounds of clover hay per acre. When 8 tons of manure were applied to the potatoes without further treatment on the wheat, the yields for the same period were increased to 173 bushels of potatoes, 32 bushels of wheat, and 4300 pounds of clover hay.

Potatoes no Exception

Most Ohio soils respond well to applications of phosphorus, regardless of the crop to which it is applied. In the experiments just mentioned 320 pounds of acid phosphate applied one-half on the potatoes and one-half on the wheat gave a 24-year average increase of 9 bushels of potatoes, 6 bushels of wheat, and 200 pounds of clover hay per acre over the nearest unfertilized check. In most Ohio potato fields an application of 300 to 500 pounds of acid phosphate per acre, to supplement the manure and the clover sod, will prove a profitable investment. In regions where potatoes are grown under systems of intensive culture it is customary to apply a part or all of the fertilizers in the row. However, under the systems of culture ordinarily practiced in Ohio where other crops in rotation follow the potato crop, it seems advisable to distribute the fertilizer alike over all the ground in

order that the crops following may make the best use of that portion unused by the potatoes.

When Commercial Potassium Becomes Profitable

There is no doubt as to the importance of potassium in the growing of potatoes. In the early years of the potato-wheat-clover rotation at Wooster the use of acid phosphate alone resulted in the production of almost as many bushels of potatoes per acre as when the acid phosphate was supplemented with 100 pounds of muriate of potash. During the latter part of the period covered by this experiment, quite the opposite has been true. For the last 8 years reported, the 100-pound application of muriate of potash on the potatoes, followed by an additional 100 pounds on the wheat, has resulted in an increase of 24 bushels of potatoes. The acid phosphate alone during this period has not increased the yield of potatoes, altho the larger yield of wheat and clover made its use profitable. As an average of 20 years, 200 pounds of muriate of potash used as a supplement to 320 pounds of acid phosphate has been responsible for an additional 21 bushels of potatoes, 1½ bushels of wheat and a few pounds of clover. With potatoes at 50 cents and wheat at $1 a bushel, the price of muriate of potash would have to fall to $100 per ton before it could be used with profit, on the basis of this experiment. Additional acid phosphate might make the story more favorable

for the muriate of potash. Applications of manure would most certainly have an opposite effect.

With Scab-Free Seed and Soil, Limestone Helps

Experience has shown that the application of lime or limestone to an acid soil immediately preceding the potato crop greatly favors the development of potato scab. In this respect lime resembles manure, but its tendency in this direction is even more marked than that of manure. Both lime and manure exert this influence toward potato scab only when the disease is present in the soil or upon the seed planted. If the soil is free from the scab-producing organism, and if the seed before being planted is treated with formalin, no bad results will be noticed. On the other hand, lime frequently gives very considerable increase both in total yield and in the proportion of marketable tubers produced. Lime may also be necessary in order to secure clover and for the benefit of other crops in the rotation. Where potatoes are grown in rotation not oftener than once in from 4 to 6 years, and where the lime is applied 3 or 4 years in advance of the potato crop, there will be little danger of trouble with scab, if clean seed is used.

Rotations for Potatoes

Potatoes, in common with other farm crops, do best when grown in a suitable rotation. Systematic rotation of crops is not always practiced in potato growing. This is especially true of certain sections where the potato industry has developed large proportions and where potatoes are often grown con-

tinuously on the same ground for an indefinite period of years. Nevertheless, experiments have demonstrated the advisability of including the potato in a definite succession of crops. Potatoes occupy a place in the rotation similar to that held by corn. Both crops ordinarily follow clover or grass, doing well upon sod ground, and both are good crops to follow with the small grains. The following rotations are successfully practiced in Ohio and nearby states where climatic and other conditions are suitable:

Potatoes, wheat, clover.

Corn and potatoes, wheat, clover (alternating the corn and potato in successive rotations).

Potatoes, oats, wheat, clover, grass one or more years.

Potatoes, wheat, alfalfa, alfalfa.

Potatoes, oats, clover and grass, grass.

In his experiments at Wooster, Director Thorne has been led to believe that a longer interval between potato crops than that given in a 3-year rotation may be advisable in order to secure the greatest yields from that crop. Under certain conditions this objection to a short rotation might be overruled by other desirable features.

Summarizing the Discussion

Briefly stated, the following points are suggested in connection with the soil treatment for potatoes grown as one of the regular farm crops:

1. A good heavy sod, preferably of clover.

2. Ten to sixteen tons of manure per acre turned under.
3. Acid phosphate at the rate of 300 to 500 pounds per acre distributed over all the ground.
4. Lime when used, applied several crops ahead of the potato crop.
5. A definite system of rotation and, if practicable, with intervals of more than 2 years between potato crops.

PERMANENT AGRICULTURE REQUIRES SYSTEMATIC ROTATION.

CONSTRUCTIVE ROTATIONS

MAY — NO. 12

Continuous cropping is no longer a live issue, so generally are the advantages of some kind of rotation recognized. Neither is it believed by many that the rotation of crops will in itself maintain fertility, notwithstanding that but a short time ago such a doctrine was given wide publicity. Rotation does offer better opportunities for maintaining crop production at a high level than a one-crop system. There are hundreds of possible rotations and numerous good ones. The few discussed here are brought up mainly with reference to their value in systems of soil building, bearing in mind that these rotations must be practicable.

A four-year rotation of corn, oats, wheat and clover is commonly followed in northern Ohio. The order is usually as given above, but there seems to be some important advantages in changing this order to corn, oats, clover, wheat. This arrangement gives opportunity for one more clover crop, to be seeded with wheat and plowed under the following year for corn. It actually provides for clover some part or all of every year, only 18 months in the entire 4 years being without clover on the land.

Corn
Oats
Clover
Wheat

A Chance for Sweet Clover

If the clover following oats is common red or mammoth clover, that seeded with wheat may well be sweet clover put in the wheat with a disk drill early in the spring. It makes a rapid growth after wheat is removed and starts off again early next year, attaining a foot or more in height by the time of plowing for corn. For fall and spring 2 tons per acre, dry weight of top growth, is a moderate estimate, representing an accumulation of perhaps 100 pounds of atmospheric nitrogen. This amount of nitrogen is equal to that contained in about 10 tons of manure. Taking into account the effect of this deep-rooted crop on the physical condition of the soil, it probably does the corn more good than such an application of manure. Recent experiments in Illinois on this very subject strongly indicate that it does. The sweet clover may be cut in September for hay or it can be pastured from the middle of August until late fall. Under these conditions not quite so much fertility is turned over to the corn crop.

A Fine Place for Wheat

This order of rotation makes a good clover sod available for wheat instead of its having to follow a lean oats stubble. The clover sod here is plowed under at its best instead of waiting for it to run out, as is done in the old order. A sod turned under while still alive has quite a different effect on the soil than old mummified residues. The former promotes bacterial activity to a greater degree, dissolves mineral mat-

ter in the soil more effectively, and gives rise to a greater accumulation of atmospheric nitrogen thru the action of the nitrogen-fixing bacteria which live on decaying organic material in the soil. If this clover sod is plowed a month or more before time for seeding it makes an ideal site for wheat. In such a rotation at the Illinois Experiment Station, with liberal use of phosphorus, they have obtained as high as 60 bushels of wheat per acre in a season when the yield on land alongside without such treatment was less than 25 bushels.

Mammoth Clover and Soybeans Deserve Consideration

There is no objection to making the clover seeded with oats, sweet clover, and the wheat seeding mammoth clover. Sweet clover should be one of these crops for the sake of giving variety if for no other reason. Some of the difficulties now being experienced with the common clovers result from attempting to grow them too frequently on the same land. Director Thorne has suggested that once in 3 years may be too often to grow red clover. This rotation can be further improved by sowing soybeans with corn and hogging them off. Also a seeding of rye may be made at the last cultivation of corn, forming a carpet to feed on and reducing loss of nitrates in the fall. Under these conditions, with plenty of lime and phosphorus, the possibilities for rapid soil improvement are excellent. We estimate that more than twice

as much nitrogen can be returned to the soil each year as is removed by cropping.

Putting One Over on the Jointworm

Incidentally it has been pointed out that this rotation provides an effective means of controlling the jointworm which is becoming a serious wheat pest, doing more damage to Ohio wheat fields than the Hessian fly. By plowing under the wheat stubble the following spring the pupae left on the stubble are destroyed instead of being left to develop into the insects which lay eggs in the new wheat straw for another crop of jointworms.

Corn Wheat Clover Wheat

A rotation similar to the first, excepting that wheat comes in the place of oats, finds favor in some sections. In northern Ohio, where corn is husked on the stalk or hogged off, spring wheat will follow the corn. In other cases probably winter wheat will be grown. The state of Ohio has now about 1 acre of wheat to each 3 acres of other crops, and yet the acreage is not as large as it was 40 years ago. This rotation admits of a larger acreage of wheat, a crop which has come to be profitable and may become more so.

Playing Safe on Wheat

Some farmers in the level sections of northwestern Ohio have considered that the growing of winter wheat is too much of a gamble. Their difficulties, however, may be mostly overcome by better methods of soil management. The seedbed must be prepared earlier than common so that it can be well settled, and seeding must be done more

nearly on time, so that the wheat has a good growth before going into the winter. Much of the winter killing is also due to insufficient drainage, calling in some cases for more tile, but especially for a loosening up of the subsoil by the use of a deep-rooted crop. With spring wheat the things to be emphasized are early seeding and plenty of fertility. The former usually means fall or winter plowing, unless the land can readily be worked into good condition without plowing. With the best soil management it is doubtful whether spring wheat is any more subject to the whims of the season than winter wheat.

Three- or Four-Year Rotation?

It may be pointed out that these 4-year rotations are better as a rule for the land than the common corn-wheat-clover or corn-oats-clover rotations. The 4-year plans give a larger proportion of clover. No doubt some will prefer the 3-year rotations for the sake of growing corn more frequently. On many farms the same thing can be accomplished by a combination of a 4-year and the 2-year rotation of corn-wheat with clover as a catch crop.

Corn Wheat

Certain deep, fertile soils, fairly well stocked with humus, can undoubtedly be maintained at a high level of fertility with a rotation of corn and wheat. Sweet clover or mammoth clover can be seeded with wheat and plowed under for corn and the wheat straw returned to the land. If the clover is cut for hay, or pastured, and the corn

fed, manure should be available at the rate of 6 to 8 tons per acre each rotation. Under these conditions this rotation may be used in building up a soil of medium fertility.

Mr. Richard Pasher of Union County employs this system, and pastures his sweet clover during the fall. In August, 1917, he was pasturing 12 cows and 30 pigs on 11 acres of sweet clover growing in wheat stubble. He was sure that his corn crops were better each time they occurred in this rotation. This is apparently becoming a popular rotation with those who have learned the quickness with which sweet clover functions in soil improvement.

Soybeans
Wheat
Clover

For use on parts of many farms on which the soil is below medium fertility, the soybeans-wheat-clover scheme proves an especially acceptable one. Advantage is being taken of this rotation to an increasing extent in eastern and southeastern Ohio, where its merits are especially appreciated. With fair use of lime and phosphorus, the soybean seed, wheat grain and straw, and one clover crop may be sold with good prospects for the soil becoming better each rotation. If wheat grain only is sold, the remainder of the produce being fed or used in the stable and the manure returned in proportion to the crops grown, somewhat more rapid improvement would be effected.

Starting at the Bottom

For one who finds himself on a farm low in fertility, and with little capital for equipment or stock, the soybeans-wheat-clover rotation offers a very practical means of getting under way. By using 200 pounds per acre of acid phosphate and with inoculation, soybeans should make a fair crop on rather thin soil without the use of lime. According to some of the Ohio Experiment Station results wheat following soybeans has averaged 10 bushels better than wheat following corn. A little more acid phosphate, then, will make a good wheat crop. At least a few acres can be limed by this time and that much will be ready for clover. The unlimed wheat ground, if any, can be put into soybeans again and by that time enough of a start may have been made to buy more limestone.

Wheat Clover

A rotation of wheat and clover will be found very desirable on some part of any farm where a rapid means of soil improvement is needed. It is suggested with particular reference to southeastern Ohio. Wheat can be made a profitable crop on thousands of acres of what are now run-out hill pastures, some of which are really too steep for cultivated crops because of trouble from washing. If these thin pastures or meadows are plowed in July or August and well limed and phosphated, they will grow a good crop of wheat and a successful crop of clover. Sweet clover is the crop that will do best under these conditions

and that will work for most rapid soil improvement. After it has been grown once, almost any other clover will do well. In fact, farmers have demonstrated that alfalfa is altogether possible after sweet clover. On hill pasture land on the Mary Bannon Farm in Scioto County, in 1918, a yield of more than 30 bushels of wheat per acre was secured on 30 acres. Following this rather successful yield, 120 acres on the same farm were sowed to wheat last fall. In the past few weeks sweet clover has been seeded in all of this wheat.

One-Third of Ohio Is Devoted to Pasture.

PERMANENT PASTURE IMPROVEMENT

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Statistics show an average permanent pasture acreage of six and three-fourths million acres in Ohio for the 10-year period 1907-16. This is approximately one-third of the state's farm land acreage. Apparently the value of farm land in Ohio is, to a considerable extent, dependent upon the value of the pasture land. This is especially true of certain regions in southeastern Ohio where the nature of the surface makes grazing the predominant type of farming.

The Pasture Problem Is Here to Stay

In studying the question of permanent pastures one is impressed with the thought that the pasture problem is here for good. It is not a matter that is with us today and gone tomorrow. Neither is it a problem which can be solved this year and eliminated next.

In some sections there has been a downward trend in pasture acreage during the last 40 years, while other sections show an opposite tendency. Many acres now in pasture in western Ohio will some day be drained and used for the growing of cultivated crops. These same sections of the state are outstanding in the production of livestock.

It would seem, therefore, that even in those communities there must ever be some pasture land. These conditions in the more level country, together with the wide areas in the hill sections of Ohio that will never be suited to anything other than grazing, make it certain that the pasture problem is permanent.

A Hard Nut to Crack

Possibly no other subject of equal importance has received less consideration from investigators and even from farmers. The logical results of this inattention may be found in the large areas of meagerly productive pastures. There is much difference of opinion as to methods of procedure for their systematic and economic improvement. Can acid phosphate be profitably used on thin grazing land and if so, how much? Will it pay to lime hillside pastures? Can poverty grass and cinquefoil be replaced by bluegrass and white clover? Is it an economical proposition to attempt? We must admit that such questions are most difficult to answer. The peculiar difficulties involved in the handling of pastures were long ago appreciated by the English people, whose experiences were crystallized in the old adage, "To break a pasture will make a man, but to make a pasture will break a man."

No Question About Phosphorus

Much of our permanent pasture land is deficient in phosphorus. This is especially true of those pastures which were preceded by some years of

cultivated cropping. Many pastures are located on soils which were originally very low in the supply of this much needed element. It is therefore, quite natural that those farmers who try a dressing of acid phosphate or bone meal generally find it works a decided improvement in their pasture sods. Its effect is particularly noticeable in the increased proportion of clover secured. Mr. F. H. Ballou of the Ohio Experiment Station noted the remarkable development of red and white clovers where acid phosphate was used on thin, worn, hill soils in orchard fertilization work in southeastern Ohio. The clovers came in abundantly without seeding following the application of phosphorus. Mr. I. S. Cook of the West Virginia Experiment Station secured similar results from the use of acid phosphate on hill pasture in that state, while investigations carried on by the Missouri Station in the Ozark Uplands still further confirm this evidence.

Limestone Essential

The more attention one gives to a study of permanent pastures the more he is led to believe that limestone is essential for a good sod. However, limestone sometimes fails to give satisfactory results unless accompanied by some carrier of phosphorus. As a rule, pasture land which can be plowed, fertilized and reseeded can be profitably treated with limestone. Where the lack of lime is outstanding and the cost of application not too

great, areas which do not lend themselves readily to plowing may be profitably topdressed with 2 or 3 tons of limestone per acre. In this case the returns would be less prompt, but could be expected thru a period of years.

Clover Rather Than Nitrate of Soda

Soluble nitrogen has a very striking effect upon the growth of grasses, such as bluegrass, timothy, and redtop. Its effect upon the clovers is much less pronounced. In fact, nitrogenous fertilization is likely to have somewhat of a depressing effect upon the development of the clovers. This is brought about by the increased competition developed in the vigorous stimulation and growth of the grass plants. Applications of phosphorus have quite the opposite effect. The important point to be kept in mind in this connection is that the clovers, if present, will bring in ample stores of nitrogen for the use of the grasses. There is a wonderful companionship between white clover and bluegrass. What pasture it makes! It is entirely possible that the length of life and productivity of the better bluegrass sods are in considerable degree dependent upon the white clover with which they are invariably associated.

Potash Doubtful

Certain experiments indicate that potassium is particularly essential for the growth of the clovers. Few, if any, however, have shown that commercial potash can be used with profit in improving pasture lands. Most soils contain large quantities of potas-

sium and are continually giving of their stores in amounts sufficient for a good growth of pasture plants. Especially is this true for the grasses. On certain soils it might be advisable to supply occasional quantities of potassium in order more strongly to encourage the clovers. If used it should only be in connection with some carrier of phosphorus. At present prices the use of commercial potash on pasture land is out of the question.

Weeds are Strong Competitors

One of the most difficult phases of pasture management is the successful control of weeds, brush, and briars. On land capable of producing good sods the task is somewhat easier, since the cultivated grasses will thrive under grazing sufficiently heavy to kill out or keep down most kinds of weeds and brush. Where the soil is less fertile the problem becomes more difficult. Here the more hardy weeds find less competition for plant food and more crevices and bare spots in the surface soil for the germination of their seeds. A small amount of fertilization, making conditions more favorable for the growth of desirable grasses and clovers is a decided step toward the elimination of weeds. Nevertheless, there will always be some undesirable growth to control. Bushes, weeds, and briars must go as the first prerequisite of a decent pasture. June grubbing of brush and briars followed by July or August clipping of weeds will gradually eliminate them. With a few dollars

wisely invested in fertilizers, aided by the steer, the sheep, the mowing machine or the scythe and the grubbing hoe, clean pasture ranges will result in time.

Grass Must Have a Chance in the Spring

A considerable number of farmers turn out their cattle and sheep on grass early in the spring. Occasionally a man will be found who grazes his stock thruout the year, if weather conditions will permit. Several factors will influence the time of turning out. Among these are season, amount of feed on hand, and rush of spring work. However, the withholding of stock from pasture a few weeks longer in the spring may easily prove wise economy in the end. Heavy cattle are likely to cause considerable injury by tramping holes and by breaking and cutting the sod in sliding about, if turned on before the ground has sufficiently settled. It has been demonstrated that a still better reason for delaying, somewhat, the usual time of turning out is the effect of early and continued grazing upon the plants themselves. For best development, grasses and clovers require opportunity for considerable growth before being subjected to severe clipping. The one method which farmers in general could pursue with little outlay of expense and with gradual but constant improvement in both quality and quantity of pasture produced, would require only that stock be withheld until grass has made a good strong growth in the spring.

Japan Clover of Much Promise

Scattered here and there across the tier of counties bordering on the Ohio River in southeastern Ohio, may be found this comparatively new resident among the pasture flora of this state. The coming of Japan clover is hailed as a great blessing by the farmers and stockmen of the hill sections. The plant itself is an annual, commonly growing about 3 to 6 inches high. It dies out each winter with hard freezing weather, but reseeds and comes on again late the next spring. The peculiar merits of this little clover are that it will grow on the very poorest acid soils and, once started, will spread, creeping into thin sods and covering bare spots where not even weeds can gain a foothold. It produces nodules abundantly and furnishes excellent pasture. A bunch of calves when turned out have been observed to graze across a good bluegrass sod and settle down to continuous eating on a patch of Japan clover. Another point in its favor is that it seems to be a good forerunner of bluegrass. Farmers in nearby states are high in their praise of the plant and are beginning to seed it. In order that its distribution northward may be more rapid, it might be well worth while to scatter a few pounds of this little newcomer over the bare portions of many of our hill pastures during winter or early spring in southern and southeastern Ohio.

One Way of Seeding

In the hill sections experience has evolved a method of seeding successfully practiced under those conditions. One to three tons of limestone are applied with a lime spreader. Two hundred or more pounds of acid phosphate are put on with a disk drill and accompanied by a seeding somewhat as follows: bluegrass, 4 to 7 pounds; timothy, redtop, and orchard grass, 3 to 4 pounds each; red and alsike clover, 2 to 3 pounds each; white clover 1 to 2 pounds. April seeding is preferred, but, if on account of unfavorable weather or rush of work spring seeding is delayed, August 1 to 15 seems to give equally good results if moisture conditions are favorable.